INSTRUMENT MANUAL
Version 1.0

WEB-BASED INQUIRY FOR LEARNING SCIENCE (WBI)

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Introduction

Recent science education reform initiatives (American Association for the Advancement of Science, 1993; NRC, 1996) emphasize using inquiry-based teaching to help students learn science. According to the *National Science Education Standards*, **inquiry** refers to the diverse ways in which scientists study the natural world and propose explanations based on evidence. Trowbridge, Bybee, and Powell (2000) contended, however, that drawing conclusions may be as valid a form of scientific inquiry as formulating explanations. They suggested that scientific inquiry should consist of asking questions, formulating hypotheses, designing experiments, gathering and analyzing data, and drawing conclusions.

The World Wide Web offers activities that provide opportunities to learn science through inquiry-based activities. Just like classroom-based science inquiry activities, Web-based inquiry activities (WBIs) for learning science fall along a continuum from **learner-directed** to **materials-directed**. Learner-directed activities tend to focus on individual decisions and much learner involvement in making decisions on how to complete the inquiry. Materials-directed inquiries tend to be very specific about what learners should do in order to complete the inquiry and often lead the learner towards expected conclusions and explanations. While individual teachers may hold different opinions about the desirability of the positions along this continuum, the instrument is neutral. That is, it classifies where the activity falls, rather than make a value judgment about the desirability of that position on the continuum. This manual provides guidelines for how to use an instrument designed to identify and classify science WBIs on the World Wide Web.

Procedures

General Description of the Instrument

- Two versions of the instrument are included in the Appendix of this manual. The first uses color coding to help distinguish leaner-directed from materials-directed classifications. Using a color-printed version may prove helpful when one is first getting accustomed to the instrument's categories. The second version is a plain black-and-white version of the instrument. This is the version one is most likely to use once one becomes accustomed to using the instrument.
- At the top of the instrument are two lines for Website names and URLs, each line containing two blanks.
- The left-hand blank on the first line is for the complete name of the Website.
- The right-hand blank on the first line is where you write the URL of the home page of the Website.

- The left-hand blank on the second line is for the complete name of the activity you are analyzing.
- The right-hand blank on the second line is where you record the root URL for the activity you are analyzing.
- Review the instrument. You will observe that it is a matrix made up of 5 rows and 4 columns. The 5 rows describe the five possible essential features of inquiry. The 4 columns describe the degree to which the WBI is either learner-directed (left two columns) or materials-directed (right two columns).
- Notice that there is a column descriptor at the top of each of the four columns. These statements summarize the guiding philosophy for all cells in that column. Note also that each cell in the matrix contains a sentence or two that describes what WBIs falling into that cell would exhibit as properties.

General Procedure for Completing the Instrument

- You should work methodically row by row, classifying the WBI into the cell that best matches how it addresses that essential feature of inquiry. Recognize that a WBI may not fall into a cell in each of the five rows, although an activity must match one cell in each of the first three rows in order to qualify as a WBI.
- As you complete each row in the instrument, select the **cell** in that row that matches that Essential Feature of Inquiry criteria. In the space in that cell, **write the exact words from the Website** that most closely match the descriptive sentence or sentences for the properties of that cell. If you cannot provide exact words, write a brief description describing why you feel the WBI falls into that particular cell of the row.
- **Write the Web address location for this text in the selected cell**. The Web address should include all location information displayed after the Root URL. Use a "/" to identify the Root URL.

  For example: You are evaluating *the Shell Island Dilemma* (http://www.ncsu.edu/coast/shell/index.html). You locate a list of evidence that learners are asked to analyze on the following Webpage: http://www.ncsu.edu/coast/shell/resources.html. You would write: ***/resources.html*** in the appropriate cell of the *evidence row* to identify this Website location.

Specific Guidelines for Completing the Instrument

Six sections follow. The first provides criteria for determining if an activity qualifies as a **science** WBI. While inquiries may exist in fields other than science, this instrument is designed to classify only science Web-based inquiry activities. The next six sections provide rules for determining into which cell in a particular row a WBI should be classified.

Qualification Criteria

In order for an activity on a Website to qualify as a science WBI, it must meet all 6 of the criteria in this section. These criteria are presented on a single page in the Appendix of this manual.

Criterion #1: A WBI must contain at least the first three essential features of classroom inquiry described in *Inquiry and the National Science Education Standards* (National Research Council, 2000), as modified to address the possibility of conclusions rather than explanations (Trowbridge, Bybee, and Powell, 2000):

1. Learners are engaged by scientifically oriented questions.
   Scientifically oriented questions may be stated explicitly or may be implied as a task.
2. Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.
3. Learners draw conclusions and/or formulate explanations from evidence to address scientifically oriented questions.

Criterion #2: The WBI must be learner-directed.

The WBI should be phrased in such a way that learners would perceive it as directed at them. That is, the majority of the wording used in the WBI should be directed at the learner ("you"), not at the teacher ("your students"). The following example from the *Albatross Project - Hawaii Study* (http://www.wfu.edu/albatross/hawaii/ideas.htm) is specifically directed at the student:

> *How will you use satellite tracking data?*
>
> *First decide what hypotheses you want to test, like what questions you want to answer.*

Some minor wording confusion in a WBI is acceptable, however, provided the majority of the phrasing is still directed at the learner. For instance, some WBIs may be directed at both the learner and a classroom teacher on the same Web page. The following example from *the Shell Island Dilemma*: http://www.ncsu.edu/coast/shell/index.html is directed at both (text directed at teacher in **bold**; ambiguously directed text underlined):

> ***Divide your class into different stakeholder roles***.
>
> *As you explore the resources, remember that you are in the role of a stakeholder. Think about and try to determine the current North Carolina policies regarding the placement of hard structures in public trust areas such as the beach. How does the current coastal policy affect your vested interests as a stakeholder?*
>
> *Click on your stakeholder name above to read a brief description of your stakeholder role and to see a recommended list of important resources to review.*
>
> *After reviewing the resources, prepare a statement to decide what should be the next course of action regarding the Shell Island Resort. You will present your statement in a debate to decide the future of the Shell Island Resort. Each student should complete a Position Statement Handout.*

After students have had enough time to review the resources and prepare their position statements, hold a debate to decide the next course of action.

When the debate is complete, take a vote on the proposed solutions and conclude the debate when a consensus of 2/3 of the class agrees on a proposed solution.

Activities directed solely at classroom teachers, such as teacher-centered organized lesson plans, do **not** meet the criteria of Rule #2. For example, *Square of Life* (http://k12science.org/curriculum/squareproj) is specifically directed at a classroom teacher:

Procedures

Activity #1: Project Introduction
For this activity, do the following:

1. *Introduce this lesson by reading aloud one or more of the books listed below (or choose a similar book). The goal is to engage the students' interest and curiosity and to get them excited about working with students from all over the world.*
2. *For older students you can stop occasionally and point out where some of the places they are reading about are located on a world map.*
3. *After reading and discussing the book(s) explain that they are going to start a project to learn what it is like to live in other parts of the world. Tell them that they are going to use the computer and the Internet to communicate or "talk" with other students from all around the world. Relate this to the books if possible.*

Criterion #3: The WBI must support student learning of a science concept or science content.

Science WBIs must fall into a recognized science discipline (for example, biology, chemistry, physics, environmental sciences, astronomy, oceanography). For example, science concepts might address the relationships among chemical nutrients in a stream or the distribution of genetic traits in a population. Similarly, science content might include the study of how light travels or how materials exist in different states of matter.

Criterion #4: The WBI must be Web-based. That is, a WBI is more than printed material placed on the Web, describing how an inquiry activity may be completed. Instead, a WBI should go beyond simply being reformatted text from a printed sheet. It should be enhanced or customized to take advantage of the features of the Web to deliver instruction.

WBIs may provide hypertext links or offer students access to additional materials including data, email, video, graphics, animation, audio, virtual reality, simulation, or other forms of interactivity. A hypertext link is underlined text that takes the user either to an area within a Website that provides additional information or to an external Website that provides such information.

Space Food and Nutrition (available online at http://spacelink.nasa.gov/products/Space.Food.and.Nutrition/) is an example of a Web-delivered print material that would not be considered a WBI. This Website offers activities from printed materials that are not enhanced for delivery on the Web, other than including hypertext links for navigation within the document. In fact, the very same materials are available from the site as a downloadable 1.9 MB PDF file. Another Website, *EnergyNet* (available online at http://www.energynet.net) consists of a downloadable PowerPoint presentation for use in class by the teacher. *Space Food and Nutrition* and *EnergyNet*, therefore, do not qualify as WBIs.

Criterion #5: Evidence used in a WBI should be of the same type an actual scientist would use.

For example, WBIs might contain links to rich databases of real-time scientific data, such as meteorological data that learners can use to examine trends in weather patterns. Web-based data might also be empirical data collection by a learner and then shared with others in an online database. Such data may be either learner-collected using a hands-on laboratory protocol supplied (or suggested) by the Website, or may be provided to the learner in the form of self-contained data sets. Learners may also collect data for analysis remotely in real time or near-real time.

Criterion #6: Conclusions and/or explanations must involve reasoning.

Conclusions and/or explanations in WBIs should be more than simple data analysis and reporting. Conclusions/explanations may include task-oriented activities, such as locating the optimal placement of an observatory, figuring out the life expectancy of an animal using a simulation, or explaining observations (for instance, the appearance of bread mold).

While the intent of hints and immediate feedback in an activity is to support learner inquiries, if learners choose such support prior to completing the inquiry or before giving thought to what they have found, the inquiry process may be "short-circuited." That is, the activity may cease to be inquiry. *Fun With Fomites* (http://www.microbe.org/experiment/fomites.asp) is an example of an inquiry that may be "short-circuited." If learners access the immediate feedback links on this Website, not only are they told how to interpret the data, but they are also provided with reasoning to draw a conclusion/formulate an explanation. An activity in which the learner no longer has any major responsibilities for data analysis or reasoning is no longer inquiry.

When you encounter a site where learners control seeing such hints and feedback, you should note on the instrument if you believe that seeing them would end the inquiry. You can then classify the activity as a WBI, provided learners do not use the hints or feedback (and you should note that fact on your completed form in the conclusions/explanations row). Of course, if learners cannot control the presentation of hints or feedback and the content of such hints and feedback eliminates the required learner reasoning, you must disqualify the activity as a WBI (and note on the instrument why you have done so – usually by quoting relevant hints, feedback, or conclusions/explanations and noting that their appearance could not be controlled by the learner).

General Classification Rules

The following are general rules designed to help you make decisions about which cell in a row best matches what a WBI offers. These rules are presented on a single page in the Appendix of this manual.

Rule #1: When in doubt, use the **philosophy column description** located at the top of each column to make decisions. These descriptions guide your cell selections.

Rule #2: When several activities are presented in a clear sequence leading to a final activity that is dependent upon completing those earlier activities, treat the full set of activities as one WBI.

For example, *Navigational Vectors* (http://k12science.org/curriculum/vectors/) requires learners to work through a sequence of learning tasks that culminate in a final activity addressing the scientifically oriented question.

Rule #3: When a WBI consists of multiple activities and these activities fall into different cells, note each activity's URL in the appropriate cell when completing the instrument.

For example, **collaborative experiments** in WBIs illustrate two ways to classify evidence, each calling for categorization in a different cell. First, the learner is provided with a protocol and collects certain data (L1). These data are then contributed to a collective database. Next, the WBI provides learners with cumulative data from remote geographical placements and instructs the learner in how to analyze the cumulative data (M1). Thus, in collaborative experiments, there is first a learner-centered component (L1), followed by a materials-centered component (M1). You would note this in the appropriate two cells of the evidence row on your completed form. Examples of collaborative experiments include *Boil, Boil, Toil, and Trouble* (http://k12science.org/curriculum/boilproj/index.html) and *KanCRN - Keeping an Eye on Ozone* (http://kancrn.org/ozone/).

Question Rules

The following rules are designed to assist you in selecting appropriate cells for WBI activities in the first row.

Rule #4: When a WBI prompts learners to formulate their own questions or hypotheses to be tested, it should be placed in the L2 *question* row cell.

An example from the *Albatross Project* (http://www.wfu.edu/albatross/hawaii/ideas.htm) illustrates this:

> "*Are these hypotheses correct? If they are, keep 'em. If they're not, chuck 'em.*

> *You can think up lots of other hypotheses to test to advance albatross science! Do it! Also, check out the details below. You'll need to know them."*

Rule #5: A WBI that suggests topic areas or provides samples to help learners formulate their own question or hypothesis should be placed in the L1 cell of the *question* row.

WOW: Investigating Data Interpretation (http://wow.nrri.umn.edu/wow/student/data/inquiry.html) suggests possible topics:

> *"In this lesson you will formulate and answer your own research question. Your question can be a water quality issue you have always wondered about, a class topic you wish to explore in greater detail, or an issue that has been in the news recently*."

An example from the *Water on the Web* (http://wow.nrri.umn.edu/wow/student/data/inquiry.html) illustrates how a WBI might provide samples:

> "For example, look at the following series of data visualization images from the Profile Plotter that are shown below. What relationship(s) among the data might you hypothesize based on these images?"
> [A series of three data visualizations is provided].

Rule #6: A WBI that offers the learner lists of questions or hypotheses from which to select should be placed in the M1 cell of the *question* row.

For example, *Boil, Boil, Toil, and Trouble* (http://k12science.stevens-tech.edu/curriculum/boilproj/questions.html) offers such a list:

> *"The questions below are suggestions for help in determining a hypothesis for the project, follow-up discussions or further exploration. Students could address some of these questions or try to make comparisons of their own. Students could address some of these questions in their final reports.*
>
> 1. *Which factor in the experiment showed the strongest correlation to boiling point? What "proof" do you have to back up your answer?*
> 2. *What was your original hypothesis? Were you surprised at your results? Were you surprised at other classes' results?*
> 3. *What explanation can you give for your results?*
> 4. *Pick a different location from where you are. Predict what the boiling point of water would be at that location. Would it be higher or lower than what you found at your location? Why?*
> 5. *How important is accuracy of measurements in this experiment? Were there any possibilities for inaccurate measurements in your experiment? What might they be?*
> 6. *What would you change if you could repeat the experiment?*
> 7. *Is there another variable you would like to test to see how it might affect boiling point?"*

Rule #7: When a WBI directs the learner to investigate a specific stated (or implied) question/hypothesis, that WBI should be placed in the M2 cell of the *question* row.

For instance, *Find Out Why - What Wrap Does the Best Job at Protecting Holiday Treats?* (http://www.nsf.gov/od/lpa/events/fow/fowtfkv2n2/htm/wrapfun.htm) provides two such questions:

> *What is the best wrap to use for each treat?*
> *Can you use the same type of wrap for every treat?*

Alternatively, scientifically oriented questions may be stated as a task.

For example, *Athena - Predicting the Weather* (http://www.athena.ivv.nasa.gov/curric/weather/hsweathr/index.html) states an explicit task:

> *"Your task now is to make a forecast for the next several days and compare it with the real weather that occurs."*

This statement can be converted into a scientifically oriented question to engage the learner. The implicit question in this WBI becomes, "How does your forecast for the next few days' weather compare to the actual weather?"

Evidence Rules

The following rules are designed to help you decide which cell in the second row best matches what a WBI offers.

Rule #8: If the learner collects data outside the Website, then the WBI is placed on the **L** side of the instrument. If the WBI provides the learner with data, the WBI is placed on the **M** side of the instrument. M1 and M2 WBIs are further distinguished by the amount of direction the WBI provides about how data should be analyzed. To see how to classify data collection in each of the four cells, see rules 9 - 12. They provide examples and more detail on how to make placement decisions.

Rule #9: When the learner determines what constitutes evidence and develops procedures and protocols for gathering relevant data (as appropriate), the WBI is classified as L2 in the *evidence* row.

The *Remote Access Online Real-Time Science Experiment-- Biological Clocks in Nature – Student Activity* (http://www.cbt.virginia.edu/Olh/middle/activ_m/nature.html) suggests a possible data-collection protocol:

> "*Design a method for recording what you are observing. Remember you can use any of your senses. For example, you may want to tape record the noises you hear*."

Rule #10: When a WBI tells learners to collect certain data, or only provides a portion of the needed data, it should be classified as L1 in the *evidence* row.

Often the WBI provides protocols for data collection. For example, *Bagheera (CS2-8)* (http://www.bagheera.com/inthewild/class_activities.htm) provides only a portion of the needed data; in this case, only the database field names:

> "*Design a database of the extinct species in this curriculum that includes the following categories of information:* ***species****;* ***scientific name****;* ***classification*** *(e.g., mammal, reptile, bird, amphibian);* ***location*** *(e.g., Brazilian rain forests);* ***habitat*** *(e.g., forest, ocean, grassland);* ***population decline over time causes of endangerment*** *(or causes of extinction, if extinct)*."

In a different L1 example in the *evidence* row, the *CERES Project- Mountainquest* WBI (http://btc.montana.edu/ceres/html/mountainquest.htm) directs learners to an external Website to collect data.

Rule #11: WBIs that provide data and ask learners to analyze them are classified as M1 in the *evidence* row.

For example, *Carolina Coastal Science - Relocating a Lighthouse* (http://www.ncsu.edu/coast/chl/index.html) states:

> *Here are the Web-based resources to use to identify and investigate the issues:*
> [A list of hypertext links to resources on the Website is then provided]

Rule #12: WBIs that provides data and direct learners to analyze those data in specific ways should be classified as M2.

For example, the *Genetics Science Learning Center - The Farmer's Bones* (http://gslc.genetics.utah.edu/society/farmer/index.html) provides specific directions:

> *1. Click on each graphic for a larger representation.*
>
> *2. Identify the bone as well as any distinguishing characteristics. Write these down in the space provided.* *****Remember... a good scientist writes everything down.***

Conclusions/Explanations Rules

The following rules are designed to assist you in selecting appropriate cells for WBI activities in the third row.

Rule #13: The amount of direction a WBI provides the learner is the main determinant of whether an activity is placed on the **L** or **M** side of the instrument in the *conclusions*/*explanations* row.

Rule #14: A WBI is classified as L2 in the *conclusions*/*explanations* row if the WBI prompts learner to analyze data and formulate own conclusions/explanations.

The following examples illustrate this:

> "Can you think of anything that may explain your results?"
> (From *CIESE Online Classroom Projects - Down the Drain*
> http://k12science.org/curriculum/drainproj/)

> "Compare your graphs. Can you draw some conclusions?"
> (From *Bagheera* (G2-1 & G2-2)
> http://www.bagheera.com/inthewild/class_activities.htm)

> "Consider possible explanations for your experimental results."
> (From *Water on the Web - Investigating Aquatic Respiration* -
> http://wow.nrri.umn.edu/wow/student/aquatic/inquiry.html)

Rule #15: A WBI is classified as L1 in the *conclusions*/*explanations* row if it provides learners with ideas to help them think about how evidence leads to conclusions/explanations, but does not cite specific evidence.

Water on the Web -- Investigating Data Interpretation
(http://wow.nrri.umn.edu/wow/student/data/inquiry.html) is a good example:

> *Sometimes, data are found that defy the observed pattern. These are known as data outliers. Rather than dismiss them as unimportant, try to determine their cause. (e.g.: Is the probe working properly?) Sometimes outliers lead to new and interesting interpretations of the data. Were there any outliers in the data you collected? Be prepared to explain how you chose to handle outliers in your data analysis.*

Rule #16: What distinguishes M1 and M2 WBIs from one another is whether they are verification-type activities or not.

If the WBI directs learner attention (often through questions) to specific pieces of evidence to draw their own conclusions or formulate explanations, the WBI is classified as M1, while if it does this to lead learners to a predetermined correct conclusion/explanation, it is classified as M2.

Carolina Coastal Science - Shell Island Dilemma
(http://www.ncsu.edu/coast/shell/index.html) is an example of an M1 WBI for the *conclusions*/*explanations* row, since the learner is investigating an authentic problem that has no known solution.

Boil, Boil, Toil and Trouble (http://k12science.stevens-tech.edu/curriculum/boilproj/example.html) is an example of an M2 WBI for the *conclusions*/*explanations* row, since the relationship of the boiling point of water at different elevations is already documented and the learner is simply verifying those data through calculations.

Alternative Conclusions/Explanations Rules

The following rules are designed to help you decide which cell in the fourth row best matches what a WBI offers.

Rule #17: WBIs that provide a "catalyst" to prompt learners to examine other resources and form connections to conclusions/explanations independently (without guidance) are classified as L2 in the *alternative conclusions/explanations* row. Catalysts are designed to encourage the learner to think about the possibilities, but L2 alternative conclusions/explanations WBIs do not provide learners with hypertext links to sources of information about alternative conclusions/explanations.

Examples of catalysts include:

> *Can you come up with possible explanations for the few stray values that occur along the growth curve?*
> (From *Chickscope*
> http://chickscope.beckman.uiuc.edu/explore/biological_imaging/)
>
> *Consider possible explanations for your experimental results.*
> (From *Water on the Web - Investigating Aquatic Respiration*
> http://wow.nrri.umn.edu/wow/student/aquatic/inquiry.html)

Rule #18: If the WBI contains hypertext links to relevant scientific knowledge that might lead to alternative conclusions/explanations, it is classified as L1. A hypertext link consists of underlined text on which a learner clicks and is taken either to an area within a Website that provides additional information or to an external Website that provides such information. The WBI may or may not refer to these links.

An example of a WBI that provides hypertext links to alternative conclusions and/or explanations but does not refer to them, is *CERES Project- Mountainquest* (http://btc.montana.edu/ceres/html/mountainquest.htm). In this WBI, the learner must independently examine other resources containing relevant alternative conclusions/explanations that are embedded in team assignments. These hypertext links are not explicitly cited and the learner must independently decide to use this information.

An example of a WBI that directs learners to hypertext links to relevant scientific knowledge is *Carolina Coastal Science - Shell Island Dilemma* (http://www.ncsu.edu/coast/shell/index.html). This WBI provides, among its hyperlink resources, alternative explanations from coastal geologists about the effects of building a hard structure at a migrating inlet.

Rule #19: If the WBI contains no hypertext links to relevant scientific knowledge that might lead to alternative conclusions/explanations, but identifies, suggests, or implies relevant scientific knowledge or possible connections, it is classified as M1.

An example of a WBI that identifies relevant scientific knowledge might be one in which students investigate suspected agricultural pollution in Lake Erie and are reminded that the Environmental Protection Agency maintains an online database of industries that discharge pollutants into the lake.

An example of a WBI that suggests or implies possible connections to alternative conclusions/explanations is *Water on the Web - Investigating Data Interpretation* (http://wow.nrri.umn.edu/wow/student/data/inquiry.html). This WBI provides the following questions to assist learners in thinking about their results:

> *Was data collected by RUSS possibly affected by external factors? Did you find any outliers? How can the outliers be explained?*

Rule #20: A WBI that explicitly states specific connections, but does not provide hypertext links is classified as M2 in the *alternative conclusions/ explanations* row.

For example, *KanCRN - How Does Your Cookie Crumble?* (http://kancrn.kckps.k12.ks.us/cookie/index.cfm) presents questions that identify other possible connections:

> *Do most males like the same brand of cookie? Do most ten year olds like the same brand of cookie? Did most ten year old males choose the same "most important characteristic"?*

Communication Rules

The following rules are designed to help you select appropriate cells for WBI activities in the fifth row.

Rule #21: The intent of communication is to share explanations and conclusions in order to permit one's fellow scientists to "ask questions, examine evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations" (NRC, 2000, p. 27). This is mirrored in the content standards:

Grades K-4. Students should begin developing the abilities to communicate, critique, and analyze their work of other students. This communication might be spoken or drawn as well as written (NRC, 1996. pp.121-122).

Grades 5-8. "With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations (NRC, 1996, p.148).

Grades 9-12. Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments (NRC, 1996, p.176)

Rule #22: Simply sharing data on a Web-based form does not constitute communication. Communication is of the conclusion/explanation, not the data.

For example, *Mission to Eros: Rendezvous with an Asteroid* (http://k12science.stevens-tech.edu/nasa2/) does not qualify as the type of communication intended for the fifth essential feature of a WBI, since all learners do is post data to a database.

Rule #23: In order to qualify as having appropriate communication, a WBI must require learners to justify conclusions and/or explanations and share that information with an "audience," not simply submit that information to the teacher. Simply completing a worksheet or stating one's conclusion in a blank or field, therefore, does not qualify as communication unless there is sharing with an audience other than the teacher. An audience might consist of fellow students, other users of the Website, the Website's developer(s), or a scientist.

Two examples make this distinction clear:

KanCRN - Keeping an Eye on Ozone (http://kancrn.org/ozone/) provides learners with an area to publish findings and conclusions on a Website. Therefore, it would qualify as appropriate communication and be classified in a cell in the *communication* row.

The *Studying the Chemistry of Oxygen Solubility* (http://wow.nrri.umn.edu/wow/student/oxygen/study.html) is displayed as a worksheet that would be submitted to an instructor. This Website would not qualify as using appropriate WBI communication, since the activity's "interpretation of results" is not shared with an audience.

Rule #24: Using right-sounding words is not enough; the WBI must actually solicit communication of conclusions/explanations.

Don't be fooled by wording. Some Websites imply that they are providing learners with authentic communication opportunities, but do not deliver on that promise. For example, The *Remote Access Online Real-time Science Experiment Website* (http://www.cbt.virginia.edu/Olh/exp.html) states on the opening page that learners will "share conclusions with other scientists from all over the world." However, this does not appear to be the case. Although the Website implies communication by using terms such as *communicate, e-mail,* and *talk to* throughout the Website, students do not communicate conclusions or explanations on the Website and e-mail appears to be used solely to ask scientists questions about the data themselves.

Rule #25: What determines whether a WBI uses appropriate communication is what the WBI solicits, not what learners actually submit to the Website.

The *Kancrn - Keeping an Eye on Ozone* (http://kancrn.org/ozone/) WBI specifies a specific format for learners to use when they communicate their conclusions, a format including certain sections. Examining actual reports, however, reveals that the specified *Data Analysis*, *Conclusions*, and *Future Research* sections of submitted student reports often have not been completed. By design, the WBI called for appropriate communication; that is, of conclusions and/or explanations. While learner response may

affect the quality of learner experience, it does not change the intended communication function of the WBI.

Rule #26: If instructions in the WBI about communication do not address content and/or layout, the WBI is classified as L1 or L2 in the *communicate* row. If those instructions focus on content and/or layout, the WBI is classified as M1 or M2. Rules 27 and 28 below clarify how to distinguish between L1 and L2 WBI communication, while rule 29 clarifies how to distinguish between M1 and M2 WBI communication.

Rule #27: WBIs that are very open-ended in terms of learners making decisions about techniques to use in presenting their results fall into the L2 cell of the *communicate* row. These WBIs remind the learner of the general purpose of communication and the need for communication, but do not provide specific guidance.

For example, the *Chickscope* activity (http://chickscope.beckman.uiuc.edu/explore/biological_imaging/) prompts the learner: *Share your results, conclusions, and questions with other classrooms on the Web.*

Rule #28: When WBIs talk about how to improve communication, but do not suggest specific content or layout approaches to be used, they are classified as L1 in the *communicate* row.

For example, a WBI classified as L1 in the *communicate* row might well suggest that the learner be sensitive to some aspects of his intended audience, such as reading or grade level, science expertise, or prior experience with the topic.

For example, *Down the Drain* (http://k12science.org/curriculum/drainproj/) provides the learner with guidelines for communicating and sharing results:

> "It is important to share what you have learned with others. Scientists often find solutions to problems by knowing the results of other scientists' experiments. Communicating your results is often the first step to clearly identifying a problem and beginning to think about possible solutions.
>
> Describe Your Results
> What did you learn after looking at all the data? What summary statement can you make describing what you found?
>
> Possible Explanations
> Can you think of anything that may explain your results? Are there any factors that might change your results? How might you go about confirming your results? What, if anything, should be done by you or others based on your findings?
>
> Share Your Results
> Think of ways you can share what you learned with others. Here are some possibilities:
> - Let members in your household know the results of your study.
> - Write a short report or make a poster describing what you learned and share it with your classmates.

- Try e-mailing participants from other parts of the country or world who reported data and share your findings with them.
- Submit a short report or digital images describing what you learned for posting in the Student Area of this web site. "

Rule #29: Distinguishing between M1 and M2 WBIs in the *communicate* row is based on how directive they are about the learner's presentation. WBIs that suggest possible content and/or layout for the presentation fall into the M1 cell, while WBIs with clear specifications for the content and/or layout to be used to communicate the conclusion/explanation fall into the M2 cell.

The CERES Project - Moonquest (http://btc.montana.edu/ceres/html/Quemoon1.html) is classified as M1:

> *Your job is to report the findings of the Historians and the Fact Finders to the class. You will work with the Graphic Design team to create a presentation that's out of this world. How you make the presentation is limited only by your imagination: You can use graphs, charts, overheads, computer graphics, etc.*

The *Athena - Predicting the Weather* activity (http://www.athena.ivv.nasa.gov/curric/weather/hsweathr/index.html) is classified as M2:

> *As a weather forecaster you must explain these maps to your viewing or reading audience. Write a weather report explaining your forecast sequence. Include forecasts for Chicago, Memphis, and Denver. Discuss changes in pressure, wind direction, wind speed, temperature, and sky condition.*

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Appendix

On a single page each, the following are presented in this appendix:

1. WBI Qualification Criteria Chart
2. Color version of the instrument (using colors to indicate the four points on the continuum from learner directed to materials directed)
3. WBI Classification Rules Chart
4. Black-and-white version of the instrument

WBI Qualification Criteria Chart

Criteria	Title	Descriptor
1	**Three Inquiry Essentials**	A WBI must contain at least the first three essential features of classroom inquiry described in *Inquiry and the National Science Education Standards*: **1.** Learners are engaged by scientifically oriented questions that are stated explicitly or implied as a task. **2.** Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions. **3.** Learners draw conclusions and/or formulate explanations from evidence to address scientifically oriented questions.
2	**Learner Centered**	The WBI should be phrased in such a way that learners would perceive it as directed at them. The majority of the wording used in the WBI should be directed at the learner ("you"), not at the teacher ("your students").
3	**Student Learning Science Concept or Content**	The WBI must support student learning of a science concept or science content. Science WBIs must fall into a recognized science discipline (biology, chemistry, physics, environmental sciences, astronomy, oceanography, and the like).
4	**Web-Based**	The WBI must be Web-based. A WBI is more than reformatted text from printed sheets placed on the Web, describing how an inquiry activity may be completed. Instead, it should be enhanced or customized to take advantage of the features of the Web to deliver instruction.
5	**Scientific Evidence**	Evidence used in a WBI should be of the same type an actual scientist would use.
6	**Conclusions or Explanations Involve Reasoning**	Conclusions and/or explanations in WBIs should be more than simple data analysis and reporting. They must involve **reasoning**.

Website Name: _____ Website URL: _____

Specific Activity Name: _____ Specific Activity (Root) URL: _____

	Learner Directed		Materials Directed	
Essential Feature of Inquiry	**L2: Learner-driven with much initiative and independence.**	**L1: Decisions to make, but support & scaffolding, particularly with process.**	**M1: Much selecting from provided materials. Limited choices.**	**M2: Materials-driven. Few choices and much direction given.**
Learners are engaged by scientifically oriented **QUESTIONS.**	Prompts learner to formulate own question or hypothesis to be tested.	Suggests topic areas or provides samples to help learner formulate own question or hypothesis.	Offers learner lists of questions or hypotheses from which to select.	Provides learner with specific stated (or implied) question/hypothesis to be investigated.
Learners give priority to **EVIDENCE,** which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.	Learner determines what constitutes evidence and develops procedures and protocols for gathering and analyzing relevant data (as appropriate).	Directs learner to collect certain data, or only provides portion of needed data. Often provides protocols for data collection.	Provides data and asks learner to analyze.	Provides data and gives specific direction on how data to be analyzed.
Learners formulate **CONCLUSIONS** and/or **EXPLANATIONS** from evidence to address scientifically oriented questions.	Prompts learner to analyze evidence (often in the form of data) and formulate own conclusions/explanations.	Prompts learner to think about how analyzed evidence leads to conclusions/explanations, but does not cite specific evidence.	Directs learner attention (often through questions) to specific pieces of analyzed evidence (often in the form of data) to draw conclusions and/or formulate explanations.	Directs learner attention (often through questions) to specific pieces of analyzed evidence (often in the form of data) to lead learner to predetermined correct conclusion/explanation (verification).
Learners evaluate their conclusions and/or explanations in light of **ALTERNATIVE CONCLUSIONS/ EXPLANATIONS,** particularly those reflecting scientific understanding.	Prompts learner to examine other resources and make connections to conclusions and/or explanations independently ("Catalyst"). Provides no hyperlinks to relevant scientific knowledge intended to help learner formulate alternative conclusions and/or explanations.	Provides hypertext links to relevant scientific knowledge that may help identify alternative conclusions and/or explanations. May or may not direct learner to examine these links, however.	Does not provide hypertext links to relevant scientific knowledge to help learner formulate alternative conclusions and/or explanations. Instead, (1) identifies related scientific knowledge that could lead to such alternatives or (2) suggests or implies possible connections to such alternatives.	Explicitly states specific connections to alternative conclusions and/or explanations, but does not provide hypertext links to support formulating such alternatives.
Learners **COMMUNICATE** and justify their proposed conclusions and/or explanations.	Reminds learner of general purpose of communication and/or need for communication, but gives no specific guidance.	Talks about how to improve communication, but does not suggest content or layout.	Suggests possible content to include and/or layout that might be used.	Specifies content to be included and/or layout to be used.

WBI Classification Rules Chart

Row Topic	#	Rule
General Classification	**1**	When in doubt, use **philosophy column description** located at top of each column to make decisions. These descriptions guide your cell selections.
	2	When several activities are presented in clear sequence leading to final activity that is **dependent** upon completing those earlier activities, treat full set of activities as **one** WBI.
	3	When WBI consists of multiple activities and these activities fall into different cells, note each activity's URL in appropriate cell when completing instrument.
Question	**4**	Place in L2 if learners are prompted to formulate their own explanation or hypothesis.
	5	Place in L1 if **suggests topic areas** or **provides samples** that help learners formulate own explanation or hypothesis
	6	If **offers lists** of questions or hypotheses from which to select, goes in M1 cell.
	7	When **provides** learner with specific stated (or implied) question/hypothesis to investigate, goes in M2 cell.
Evidence	**8**	If the learner **collects** data outside Website, then WBI placed on **L** side of instrument. If WBI provides learner with data, WBI is placed on the **M** side of the instrument.
	9	When **learner determines** what constitutes evidence and develops procedures and protocols for gathering relevant data (as appropriate), classified as L2.
	10	When WBI **directs learner to collect** certain data or only **provides a portion** of needed data, classified as L1.
	11	WBIs that **provide data** and ask learners to analyze them classified as M1.
	12	If **provides data and** gives **specific direction** on how data are to be analyzed, classified as M2.
Conclusions and Explanations	**13**	Amount of **direction** WBI provides learner is main determinant of whether placed on **L** or **M** side in this row.
	14	Classified as L2 if **prompts** learner to analyze data and **formulate own** conclusions/explanations.
	15	Classified as L1 if **prompts** learner to think about how evidence leads to conclusions/explanations, but does **not cite specific** evidence.
	16	What distinguishes M1 and M2 WBIs from one another is whether are **verification-type activities** or not:
		If directs learner attention (often through questions) to specific pieces of evidence to draw own conclusions or formulate explanations, classified as M1.
		If directs learner attention (often through questions) to specific pieces of evidence to lead learners to **predetermined correct conclusion/explanation**, classified as M2.
Alternative Conclusions and Explanations	**17**	WBIs that provide a "catalyst" to **prompt learners** to examine other resources and form connections to alternative conclusions/explanations **independently** (without guidance) are classified as L2. Catalysts designed to encourage learner to think about possibilities, but L2 alternative conclusions/explanations WBIs provide **no hypertext links** to sources of information for alternative conclusions/explanations.
	18	If WBI contains **hypertext links** to relevant scientific knowledge useful in formulating alternative conclusions/explanations, classified as L1. WBI may or may not refer to the provided links.
	19	When **identifies relevant** scientific knowledge that could be useful or suggests/implies possible connections, but **does not provide hypertext links**, classified as M1.
	20	If **explicitly states specific** connections, but **does not provide hypertext links**, classified as M2.
Communications	**21**	Intent of communication is to share explanations and conclusions to permit fellow scientists to "ask questions, examine evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations" (NRC, 2000, p. 27).
	22	**Simply sharing data** on Web-based form does not constitute communication. Communication is of conclusion/explanation, not data.
	23	Communication requires learner **justify** conclusions and/or explanations and that information be shared with "audience," not simply submitting that information to teacher for assessment. Audience might consist of fellow students, other users of Website, Website's developer(s), or scientist.
	24	Using right-sounding words not enough; WBI **must actually solicit** communication.
	25	Communication is determined by what WBI **solicits,** not what learners submit.
	26	If instructions in WBI about communication **do not address** content and/or layout, classified as L1 or L2. If instructions **focus on** content and/or layout, classified as M1 or M2.
	27	WBIs that are **very open-ended** in terms of learners making decisions about techniques to use in presenting results fall into L2 cell. These WBIs **remind** learner of general purpose of communication and need for communication, but **do not provide** specific guidance.
	28	When WBIs talk about **how to improve communication**, but **do not suggest specific** content or layout approaches to be used, classified as L1.
	29	Distinguishing between M1 and M2 WBIs in this row based on **how directive** about learner's presentation:
		WBIs that **suggest possible** content and/or layout for presentation classified as M1.
		WBIs with **clear specifications** for content and/or layout classified as M2.

Website Name: _____ Website URL: _____

Specific Activity Name: _____ Specific Activity (Root) URL: _____

	Learner Directed		Materials Directed	
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